Analysis of Energy-Rescued Potential of a Hot Water Heating Network

Jibing Han Delin Wang Guansan Tian
Master Professor Professor
Shandong Jianzhu University
Jinan, China
hanjibing@sdjzu.edu.cn

Abstract: Architecture **e**nergy consumption occupies a big ratio of overrall energy consumption, while heating energy consumption is a main part of it. Therefore, analyzing the generation of heat waste is important. In this paper, based on a test of a heating and electricity factory in Jinan, we analyze the energy waste caused by hydraulic power maladjustment and improper control of heating temperature in heating season. We conclude that proper adjustment of the heating network and controlling the heating supply to change according to outdoor temperature can save much energy.

Key words: heating network; saving energy; test analysis

China is a huge energy consumption country, of which quickly developed economy leads to energy needs increase continuously. In the latest years, the architecture industry developed quickly, living standard of people improved and the Architecture Energy consumption ratio in society Energy consumption become bigger and bigger. At present the ratio is 27%, nearly to the ratio of high-developed country: 30% to 33% and the ratio will exceed 30% along with the architecture acreage increasing. Today the heating energy consumption of architecture occupies 55% or more of total architecture energy consumption and at traditional heating area (north of Chang Jiang River) the ratio is 75% to 80%, and occupies 21.4% of society energy consumption. Besides, the heating area will expand to the southern (south of Chang Jiang River) quickly. Those reason lead to heating energy consumption increase rapidly. City central heating as a main heating method is widely used for many years and the heating scope is generally large in china. But the improperly designed heating network and the lag manage method caused the heating efficiency of heating network generally low. In this paper, based on test of Thermoelectricity Plant of south suburb in Ji Nan Shandong Province, we analyze the energy loss caused by hydraulic power maladjustment and improper control of heating temperature in heating season. A conclusion is given that proper adjusting of heating network and controlling the heating supply to change according to outdoor temperature can save much energy.

1. SUMMARY OF THE PLANT

The heating area of the plant is about 2,200,000 square meters: the north branch of old architecture, 1,500,000 square meters, the south and west branch of relatively new architecture, 700,000 square meters. So the heat preservation of the southern is better than the northern. The heating diameter of the factory is about 2250 meters, while the southern is higher than the northern, the biggest fall about 90 meters. The heating source is 4 × 58.2MW hot water boilers and the delivery lift of the pump is 96 meters and the rating flux is 1100 m^3/h. From the survey we know that heat user of the south branch feel hot some time and the temperature indoor is above 18 most time, while the heat user of the north branch feel cold. And in the test we found that hydraulic pressure is very low. To find out the reason we tested the flux of the heating network then.

2. TEST AND CALCULATION OF THE HEATING NETWORK

2.1 Flux Test and Analysis

In the test, we measure the supply and back water flux of every heating exchange station. The flux we measured is the flux of every station all through the heating reason because the total water flux of the heating network changes small.

Tab.1 Water flux

Num	Des Flux	Test Flux	Ratio	Num	Des Flux	Test Flux	Ratio
1	8.43	6.17	0.732	28	74.85	73.73	0.985
2	10.15	9.46	0.932	29	76.32	55.74	0.730
3	5.19	7.14	1.376	30	29.06	20.98	0.722
4	14.93	6.02	0.403	31	63.24	105.62	1.670
5	21.78	11.57	0.531	32	28.04	26.21	0.935
6	8.42	8.42	1.000	33	10.98	6.45	0.587
7	38.36	26.31	0.686	34	84.49	85.46	1.011
8	44.67	44.67	1.000	35	11.89	6.81	0.573
9	8.73	3.25	0.372	36	19.59	13.44	0.686
10	15.24	16.12	1.058	37	6.58	5.74	0.872
11	54.65	11.32	0.207	38	5.58	4.87	0.873
12	67.05	62.55	0.933	39	12.56	12.92	1.029
13	18.19	8.34	0.458	40	11.83	5.88	0.497
14	17.96	17.12	0.953	41	4.35	12.39	2.848
15	21.18	21.18	1.000	42	27.62	14.52	0.526
16	39.43	37.23	0.944	43	80.57	74.56	0.925
17	34	22.45	0.660	44	6.06	6.7	1.106
18	6.85	9.05	1.321	45	21.7	21.7	1.000
19	20	20.09	1.005	46	176.56	176.68	1.001
20	75.97	52.65	0.693	47	51.45	52.38	1.018
21	8.64	4.56	0.528	48	66.53	31.81	0.478
22	8.73	32.78	3.755	49	77.85	45.06	0.579
23	7.98	11.47	1.437	50	50.59	35.88	0.709
24	24.02	67.24	2.799	51	73.19	20.97	0.287
25	52.01	53.09	1.021	52	54.65	36.61	0.670
26	39.04	39.77	1.019	53	17.19	11.82	0.688
27	47.84	32.74	0.684				

From the result of the test (Tab.1), we found that the water flux of the station of the north branch (Num.1~45) is relatively small, which lead to the small hydraulic pressure difference of the north station. But the relatively nearer and higher south and west branch do not have big water flux. And then we found that the opening of the most valve is small, less than 30%, after original adjusting and operation adjusting. To other word, the manager cut down heating supply of many station in order to satisfy some far station. Restriction of most valves of the heating network leads to equivalent impedance of the heating network larger and the pumps deviate from the rating operating point and at last causes diseconomy operation.

Wasting power of pump because of deviating from operating point:

$$\Delta N = Q_B \Delta H / \eta_B$$

In this heating network, Q_B =1060 m^3/h; ΔH =10m;

η_B =0.6. So: ΔN =46.3kw

In Jinan Shandong Province, the heating season is 140 days long and Price of Electricity 0.5yuan per kWh. So the total cost is:

46.3kw×24h/d×140d×0.5yuan=77784.0yuan

In the test, we augment the opening of the valve and then the characteristic curve of the pipe network change and the operating point of the pump move right and the Flux augments that is propitious to the flux distribution of the stations. But the pressure difference of the pump drops a little.

2.2 Calculation of the Energy of Heating Exchange Station

The water flux of the heating network change little although the heating season, so the energy distribution of the station can be calculation based on test water flux and supply and back water temperature.

Fig.2 indicates temperature of supply and back water of once pipe network and outdoor between 2006.3.8 and 2006.3.22 at heating exchange station Ji Yao Ju. From the figure we can find that the outdoor temperature gradually rose wavily and between 3.11 and 3.13 the temperature fell a little. To fit the outdoor temperature the once network back water temperature Changed similarly and kept about 40 .

Fig.3 indicates the changes of Academic and actual heating load between 2006.3.8 and 2006.3.22 at heating exchange station Ji Yao Ju. From the figure we can find that Academic heating load changed obviously along with the outdoor temperature and

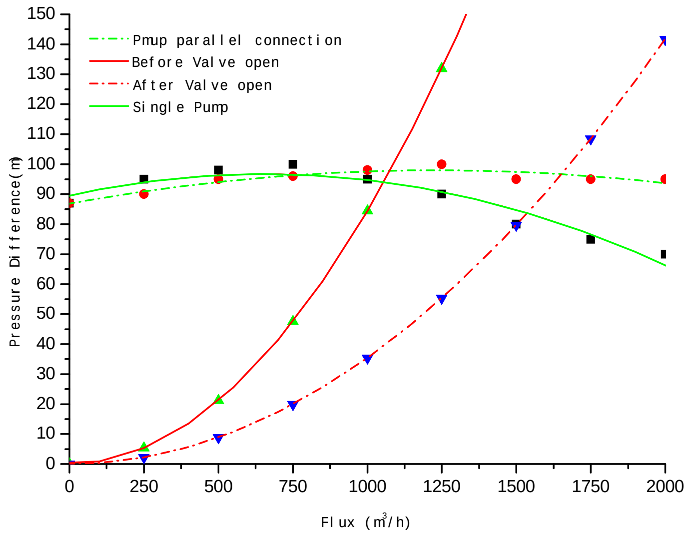

Fig.1 Operation curve of heating network and pump

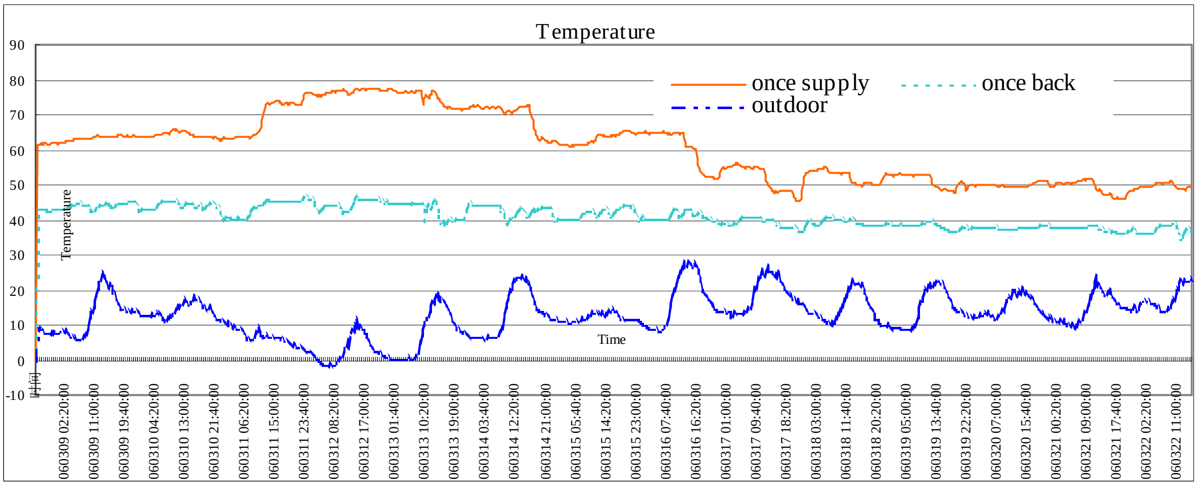

Fig.2 Temperature of supply and back water and outdoor

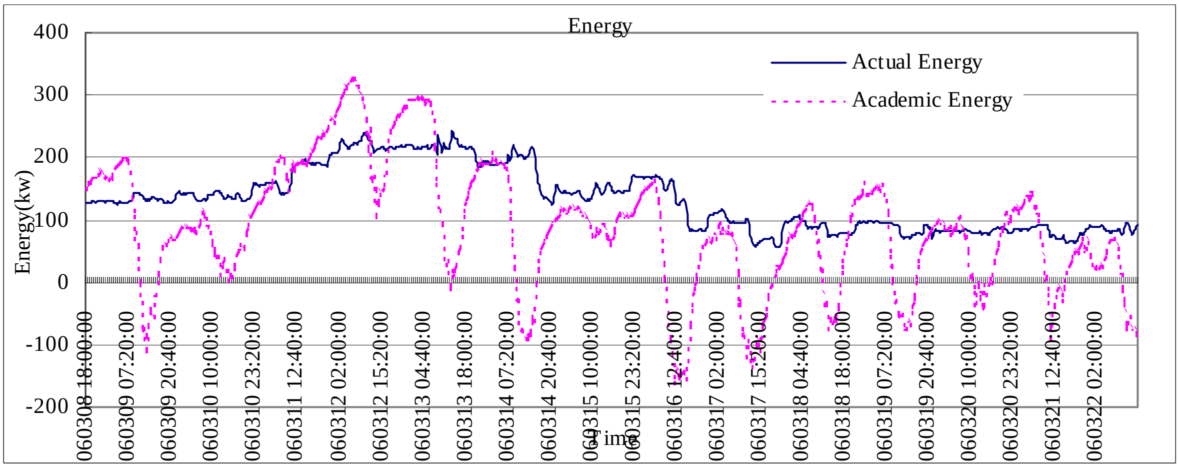

Fig.3 Academic and actual heating load

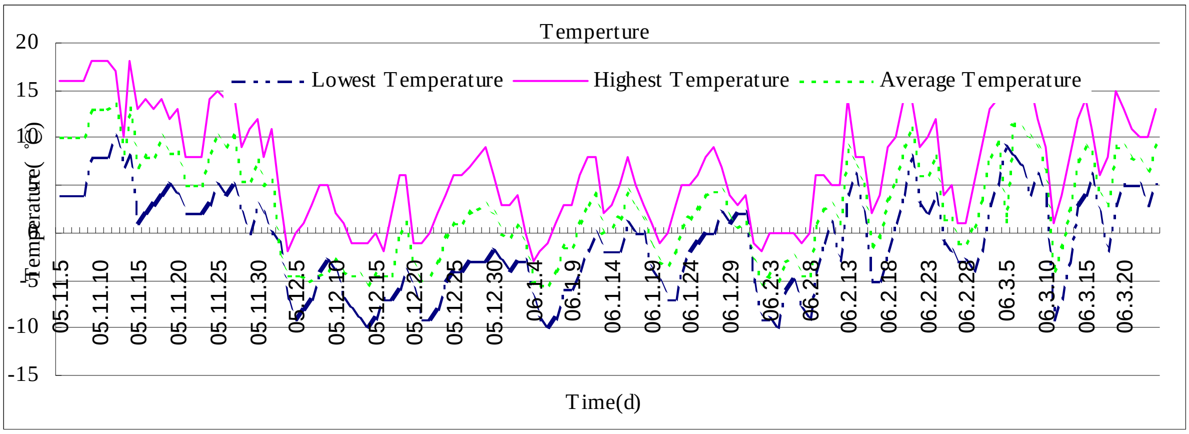

Fig.4 2005~2006 heating season Outdoor temperature

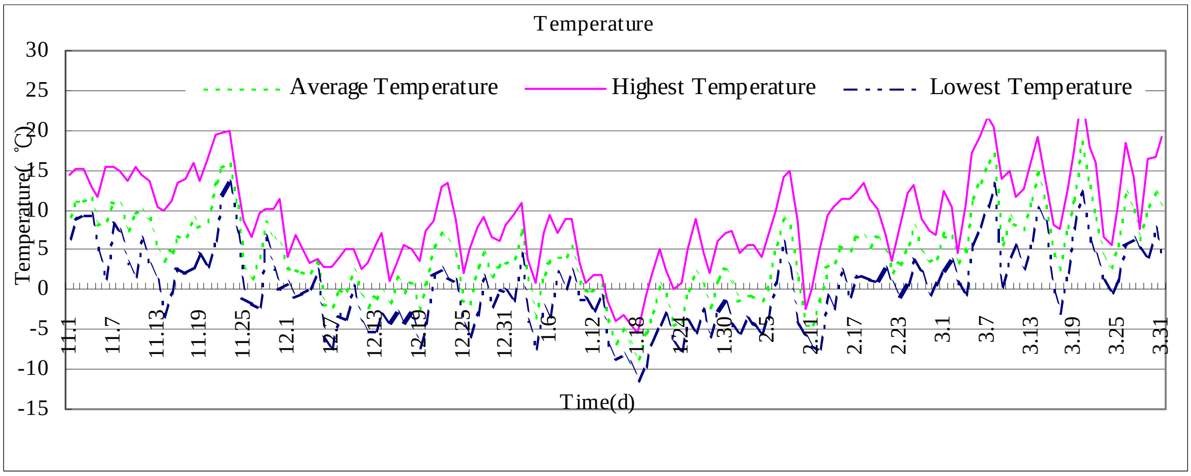

Fig.5 Typical meteorologic year Outdoor temperature

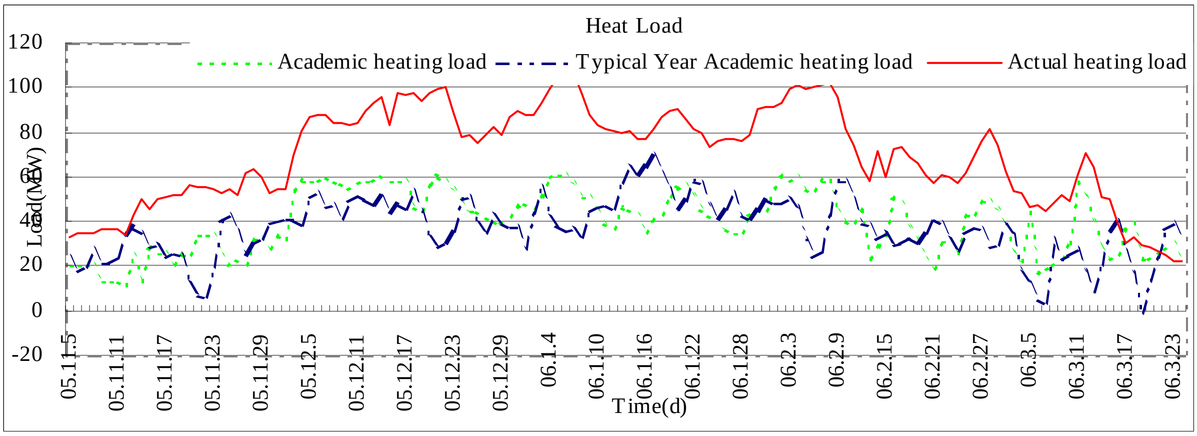

Fig.6 Academic and actual heating load

minished gradually. And the negative heating load indicates that the outdoor temperature is above 18 . To keep the indoor temperature fit to outdoor temperature, the heating supply preserves a steady value about 100KW and minished slowly.

Total academic heating load of the station is 118,908 MJ and total actual heating load of the station is 159,777 MJ. To other word proper adjusting will reduce the waste by 40,869 MJ about 25.6%.

The other two stations:

1).area: 24,633.22 m^2，test flux: 19 m^3/h, total academic heating load 162120 MJ，total actual heating load 373560 MJ，waste:211440MJ, about 56.6%.

2).area: 33,797.22 m^2，test flux: 20.976 m^3/h, Total academic heating load 292080 MJ，total actual heating load 646800 MJ，waste: 354720MJ, about 4.8%.

In this part through calculation of total academic and actual heating load based on typical meteorologic year temperature of Jinan and test water flux and supply and back water temperature, we analysis the waste heating and the reason and concluded that proper adjusting along with outdoor temperature can save much energy.

2.3 Analysis on Adjusting and Potential of Energy Rescued

Based on the typical meteorologic year temperature of Ji Nan and test temperature of outdoor and supply and back water temperature and water flux, we can calculate the heating load of the heating reason. Fig.4 indicates that outdoor temperature of 2005 to 2006 heating season is match to the outdoor temperature of typical meteorologic year in Fig.5

Through analysis of Fig.5 (without regard to solar radiation), we can partition the heating season to three phases:

1) The average temperature of the first phase is below 20 about 8~9 but the minimize temperature is above 0 . The temperature of this phase is relatively high and proper adjusting the water flux and temperature of water may save much energy.

2)The average temperature of the second phase is below 0 and the solar radiant intensity is falling gradually, so we should augment the flux and temperature of water to guarantee the indoor temperature.

3)The third phase is similarly to the first phase and the average temperature is 7 ~8 . But the outdoor temperature changes abruptly, so we need to cope with the changing weather.

Fig.6 indicates changes of the total academic and the total actual heating load of the heating pipe network. Total academic heating load of the station is 6,694,140 MJ and total actual heating load of the station in 2005 ~ 2006 heating season is 11,739,516 MJ. To other word proper adjusting will reduce the waste by 5,045,376MJ, about 43.0%, while the fall of solar radiation intensity will minish the potential of energy rescued.

3. RELATION TO THE ARCHITECTURE MAINTENANCE FRAME

In the process of test, we simulate the energy waste of Energy Rescue building in the south branch and the average energy waste is 22w/m^2, but the actual heating load is much higher than the design value (30w/m^2). The indoor temperature of new building is universally high and this lead to lowly comfort degree and highly energy waste. So the Energy saving building should be considered singly when designing and managing the heating pipe network.

4. CONCLUSIONS

Heating Energy waste as a main part of architecture energy waste is very important. But because the heating pipe network in china is relatively large and old and the design and manage level is low, the heating network waste much energy. In this paper we test a network of a factory in Jinan Shandong Province and analysis the reason. We concluded that the main reasons are improper designing and adjusting, and the supply and back water can not adjust along with outdoor temperature. Besides the heating load supply of Energy Rescued building is higher than the design value. So to save energy consumption in building, we should deal with the several problems.

REFERENCES

[1] Yi JIANG. Analysis of Large and Medium City's Heating Manner in North China, Heating Ventilating and Air conditioning, China, 2000,30(4), 30-45. (In Chinese)

[2] Weiguo HAN, Yi JIANG, Fei GUO. Energy Consumption Analysis of Several Kinds of Heating Systems. Heating Ventilating and Air conditioning , China, 2005，35(11)，106-110(In Chinese)

[3] Zhening YUAN. Heating Consumption Index Calculation and Energy Rescued Analysis of Heating Exchange Station [D]. Tian Jin: Tian Jin University. 200) 2004. (In Chinese)

[4] Data Collection of China Architecture caloric environment analysis, Tinghua University and China weather bureau. (In Chinese)